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"FRAMEWORK - CASE STUDY DESIGN FOR A
RISK BENEFIT ANALYSIS OF PESTICIDES
IN THE SPECIAL REVIEW PROCESS" --
DRAFT FINAL REPORT FOR 1985

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I. INTRODUCTION

This report summarizes the work carried out under cooperative agreement CR811200, "Framework - Case Study Design for a Risk Benefit Analysis of Pesticides in the Special Review Process," between USEPA and the Western Consortium for the Health Professions, Inc. during budget period 2 (February 1, 1985 - January 31, 1986). The work we undertook during this period falls into three major categories: (1) developing methods for estimating the benefits of pesticide use; (2) developing methods for estimating pesticide productivity; (3) and developing methods for evaluation the impacts of farmworker safety regulations. The first of these areas was addressed in two studies: one which developed a conceptual framework for incorporating the impact of agricultural policies on the welfare effects of pesticide regulation, applied it to several major crops and used it to develop IBM PC-compatible software for use by the EPA; and one which refined the methodology for obtaining estimates of the regional welfare economic impacts of pesticide regulation and applied it to regulations affecting the U.S. cotton industry. These two studies correspond to those described in Sections II and III, respectively, of the project proposal for budget period 2. As regards the second area, we refined the methodology for econometric estimation of pesticide productivity we developed in budget period 1, including preparation for publication in the American Journal of Agricultural Economics, and applied it to data on pesticide use on cotton in the San Joaquin Valley of

California. This corresponds to the study described in Section IV of the proposal for budget period 2. As regards farmworker safety regulation, we developed a framework for assessing the tradeoff between growers' revenue losses and the risk of organophosphate poisoning inherent re-entry regulation of organophosphate use on apples in Washington, California and Michigan. This study corresponds to the one described in Section V of the proposal for budget period 2. Our work in all of these areas is described in greater detail below.

II. USING WELFARE ECONOMIC METHODS TO ASSESS THE BENEFITS OF PESTICIDE USE

A. Introduction

In recent years, EPA has been urged to discontinue its use of partial budgeting techniques to assess the benefits of pesticide use and to adopt the methods of welfare economics in their place (see for example the National Academy of Sciences report, Regulating Pesticides). The application of welfare economic methods for this purpose has proven somewhat problematic, however. Earlier, we identified two central weaknesses of the standard welfare economic methodology:

- (1) The standard approach assumes perfectly competitive market clearing. However, markets for most agricultural products are influenced considerably by government intervention, notably price support programs. In the presence of such programs, market prices and quantities do not necessarily reflect socially desirable values. Having no jurisdiction over these policies, EPA must behave as a policy-taker and adjust welfare estimates to correct for the influence of these programs.
- (2) The standard approach estimates the effects of regulation only on consumers and producers in the aggregate, whereas EPA actions, because of the nature of the political process, are influenced to a considerable extent by regional or other intraindustry

or intraconsumer effects. Thus, EPA needs a method for disaggregating the welfare impacts of proposed regulations.

During budget period 2, we addressed both areas. With respect to (1), we developed a methodology for incorporating deficiency payments, the chief form of price support, into estimates of the welfare effects of regulation and applied it to five major U.S. crops. This work is described in Section B. With respect to (2), we refined the framework for disaggregating welfare effects we developed during budget period 1 and applied it empirically to the U.S. cotton industry. This work is described in Section C.

B. THE WELFARE ECONOMICS OF REGULATION IN REVENUE-SUPPORTED INDUSTRIES¹

Government regulations aimed at furthering social goals such as improved environmental quality, more equitable income distribution, etc., often reduce productivity. Policy evaluation procedures typically treat impacts on the relevant social goals as separable from impacts on the performance of the product markets affected (as is done in cost-benefit analysis, for example, or in the derivation of trade-off relations). When the affected industries appear to be competitive, traditional welfare analysis (that is, calculation of producers' and consumers' surpluses assuming competitive market clearing) is generally used to assess these impacts on product markets. However, analyses based on blanket application of the competitive model may be quite misleading; even in seemingly competitive industries, prior government intervention may influence market clearing and hence the impacts of new regulations. Accurate assessment of product market impacts thus requires that welfare analytic procedures be modified to incorporate such prior intervention.

Consider the case of pesticide regulation. Regulatory agencies typically assess the health and environmental impacts of, say, a pesticide ban separately from any impacts on agricultural product markets. Even though agriculture appears to fit the competitive model quite closely, for many commodities, producers' revenues are supported by programs such as price supports, marketing orders, and import quotas which should be taken into account in evaluating the product market impacts of the ban.

This paper examines the welfare effects of regulation on product markets affected by revenue-support programs. Section I introduces the proper welfare measures for these industries and examines the market impacts of new

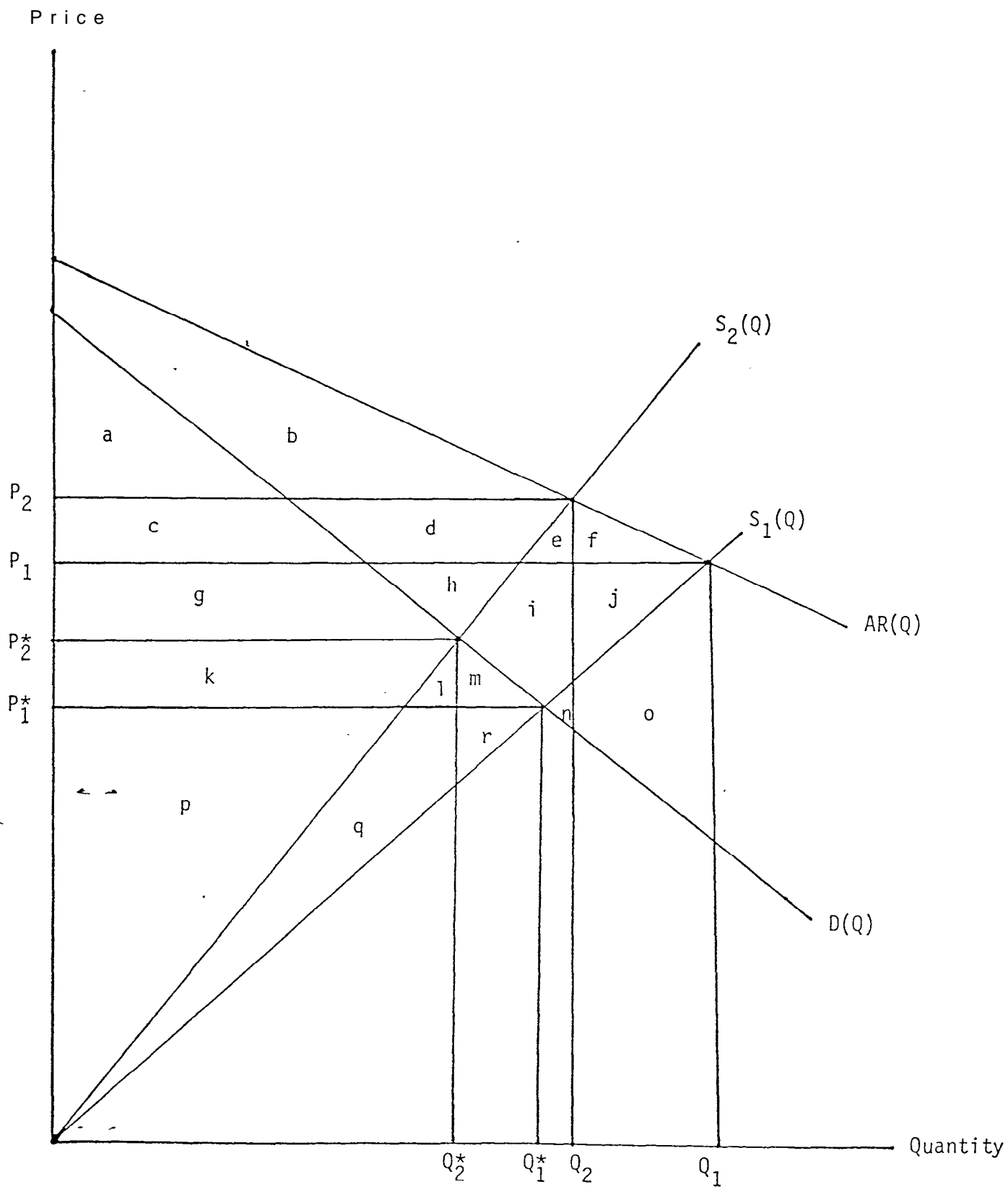
regulations. The analysis indicates that the distribution of effects between producers and consumers may be reversed qualitatively from the competitive equilibrium case and that the net market effect may, under some plausible conditions, be nonnegative. In Section II, the framework is applied to regulation affecting agricultural products subject to the current form of price supports. It is shown that the savings in the U. S. Treasury costs associated with regulation-induced reductions in output may be sufficiently large to outweigh consumers' and producers' losses. In any case, the use of the competitive model instead of the correct specification will produce biased estimates of the product market welfare effects of regulation, in particular, overestimates of the net market welfare effect. An empirical example comparing the impact of production restrictions on the five major crops covered by price supports shows that this bias in measuring the net market welfare effect may be as large as 50 percent of the true value.

I. Welfare Evaluation in Revenue-Supported Industries

Mechanisms such as price supports, import quotas, marketing orders, etc., are used in a number of important industries--notably, those with low elasticities of demand, like agriculture--to support producers' incomes, especially as output increases. These policies create situations such as that shown in Figure 1, where the effective price received by producers, given by the average revenue curve, $AR(Q)$, exceeds (inverse) consumer demand, $D(Q)$, and where the gap between average revenue and demand widens as output rises. This gap between the average revenue received by producers and consumer demand arises either from explicit government subsidies or from government policies which effectively increase market-clearing prices above competitive levels.

Figure 1

Welfare Effects of Regulation in a Revenue Supported Industry



In the case of agricultural price supports, the difference between average revenue and demand represents an explicit subsidy paid out of tax revenues. Agricultural marketing orders essentially set up discriminating monopoly schemes for allocating an industry's output among markets so that the pooled price (average revenue) producers receive exceeds demand. Import quotas effectively increase domestic excess demand above competitive levels, i.e., above the levels specified by the difference between domestic demand and foreign supply.

Figure 1 shows market equilibrium in a revenue-supported industry. Pre-regulation inverse supply is given by $S_1(Q)$ while producer price, P_1 , and output, Q_1 , are determined by the equality of average revenue and supply. The competitive equilibrium price and output before regulation are given by P_1^* and Q_1^* .

Assume that taxes are paid by consumers so that aggregate consumer welfare includes government expenditures as a negative element. Assume also that aggregate utility from consumption is measured by the area under the demand curve.² Net consumers welfare prior to regulation NCS_1 is simply the area under the demand curve less consumer expenditures (which equal producer revenues) and is, thus, given by the area $(a+c) - (h+i+j+n+o)$. This net consumer welfare measure has three components. First, the area $a+c$ represents the excess of consumer willingness to pay over actual price. Second, the negative area $h+i+j$ represents a transfer of income from consumers to producers caused by the fact that consumers buy more than they desire at price P_1 . Finally, the negative area $n+o$ represents the deadweight loss to society from excess production and consumption.

Producer welfare prior to regulation PS_1 is given by the excess of producers' revenues over costs, that is, by the area $g+h+i+j+k+l+m+p+q+r$. This, too, has three components: producers' quasi rents in competitive equilibrium ($p+q+r$) and the two transfers of consumer income caused by the increase in price ($g+h+l+m$) and in quantity purchased ($h+i+j$) above the competitive equilibrium levels.

Finally, total welfare in the market W_1 is given by the sum of producers' and consumers' surpluses and is equal to the area $(a+c+g+k+l+m+p+q+r) - (n+o)$, that is, total welfare under competitive equilibrium ($a+c+g+k+l+m+p+q+r$) less the deadweight loss $n+o$.

A. Market Impacts of New Regulation

Regulatory agencies typically have little or no influence over policies outside of their own specific jurisdictions regardless of whether such policies impinge on matters which concern them. The U. S. Environmental Protection Agency (EPA), for example, has jurisdiction over pesticide use--it rules on the legality or illegality of the use of particular pesticides for particular uses. It has no jurisdiction on preexisting policies like agricultural policy which exert influence on pesticide-use patterns; rather, it must take the existin policy environment as given. Thus, each agency is forced to behave as a policy taker, ruling within its own sphere of influence as if the policies of other agencies were fixed and immutable. In evaluating the economic costs of regulation, then, the agency must consider any prior policies as given.

Suppose that the government imposes a new, productivity-decreasing regulation on a revenue-supported industry. As Figure 1 illustrates, the new

regulation causes a leftward shift in the supply curve from $S_1(Q)$ to $S_2(Q)$ reducing output from Q_1 to Q_2 , raising the price from P_1 to P_2 , and changing the competitive equilibrium price and quantity from (P_1^*, Q_1^*) to (P_2^*, Q_2^*) .

Consider first the impact of the regulation on net consumer welfare, Net consumers' surplus after the regulation, NCS_2 , is given by the area $a - (d+e+h+i+n)$; thus, the effect of the regulation on gross consumer welfare, $\Delta NCS = NCS_2 - NCS_1$, is given by the area $(j+o) - (c+d+e)$. Again, this effect has three components: The negative area c represents the reduction in consumer income due to higher prices on desired purchases, the negative area $d+e$ represents the reduction in consumer income due to higher prices on excess purchases, and the positive area $j+o$ represents the social gain arising from the reduction in excess output from Q_1 to Q_2 .

Producer income after the regulation, PS_2 , is given by the area $e+d+g+h+k+p$ so that the effect of the regulation on producer welfare, $\Delta PS = PS_2 - PS_1$, is given by the area $(c+d) - (i+j+l+m+q+r)$. This effect has three components as well. First, the regulation causes an increase in the cost of producing the equilibrium output Q_2 equal to the area $e+i+l+m+q+r$. Simultaneously, the reduction in output causes an increase in price and hence a revenue gain equal to the area $c+d+e$; as a result, the net increase in production cost is $i+l+m+q+r$ since e is compensated for by the price increase. Finally, the reduction in output causes a reduction in quasi rents equal to the area j .

Total market welfare after the regulation W_2 is $(a+c+g+k+p) - (e+i+n)$ so that the effect of the regulation on total market welfare, i.e., the market welfare impact of regulation, $\Delta W = W_2 - W_1$, is given by the area $o -$

$(e+i+l+m+q+r)$ which equals the loss in production efficiency reflected in the increased cost of producing Q_2 , given by the negative area $e+i+l+m+q+r$, plus the reduction in the excess of cost $[S_1(Q)]$ over social value $[D(Q)]$ caused by the decrease in excess production from Q_1 to Q_2 . Alternatively, one can interpret ΔW in terms of the impact of regulation on global social efficiency. It is clear from Figure 1 that the area $m+l+q+r$ represents the increased cost of producing the competitive equilibrium quantities before and after the regulation, i.e., $m+l+q+r$ represents the market welfare impact of the regulation in competitive equilibrium. When government revenue supports are in effect, the regulation has an additional impact: By reducing excess output, it causes a change in deadweight loss from $n+o$ to $e+i+n$ --a net change of $o - (e+i)$. Thus, the area $o - (e+i+l+m+q+r)$ represents the total impact of the regulation on the social efficiency of production.

This analysis suggests regulation will tend to have different effects on welfare in a revenue-supported industry than in an industry in competitive equilibrium. In particular, when producer revenue supports are effective, (1) producers are more likely to lose from regulation; (2) consumers, as a group, may gain from regulation; and (3) new regulation may actually increase net social welfare.

Consider first the effect of regulation on producers. Whenever regulation increases the prices paid to producers (i.e., whenever demand is less than perfectly elastic), producers will be at least partially compensated for increases in production cost and decreases in sales. In industries where demand is inelastic, as is typical of those with revenue-support programs, these revenue increases will tend to exceed the sum of cost increases and sales reductions so that producers will tend to actually gain from

regulation. By increasing the elasticity of average revenue, however, revenue-support programs reduce the size of regulation-induced revenue gains ($d+d+e$) relative to cost increases ($e+i+l+m+q+r$) and sales reductions (j), making it more likely that producers will lose from regulation. The existence of revenue-support programs may thus be expected to exert a strong influence on the attitudes of producers toward regulation: While producers in these industries might well support regulation under a competitive equilibrium regime, under revenue supports, they will tend toward firm opposition.

Revenue-support programs have the opposite effect on consumers. Under competitive equilibrium conditions, consumers always lose from regulation, especially when demand is inelastic. Revenue-support programs work to reduce these losses in two ways. First, by increasing the elasticity of average revenue, they moderate price increases and, hence, increases in consumer expenditures ($c+d+e$). Moreover, as long as revenue supports remain effective, all reductions in consumption will come out of excess purchases and hence represent a gain to consumers ($j+o$). It is thus possible that, instead of losing from regulation (and in the case of inelastic demand bearing the full cost of regulation), consumers may actually gain from regulation. As a result, one would expect revenue supports to strengthen consumer support for regulations to a significant extent.

With respect to total market welfare, it is evident that the market welfare effect of regulation will be nonnegative whenever o is larger than $e+i+l+m+q+r$, so that regulation will not cause a loss in social welfare but will either be neutral or will increase social welfare. Instead of

introducing a deadweight loss, regulation decreases the size of the deadweight loss already present, at times sufficiently to outweigh producer losses. It is thus incorrect to assume a priori that regulation will cause social losses (have a negative market welfare effect) that must be weighed against a separate set of gains (e.g., of environmental quality or human health and safety). Instead, regulation may be justifiable simply because it reduces inefficiencies caused by prior policies. Regulating agricultural pesticides, for example, may be justified on efficiency grounds even apart from its effects on environmental externalities.

B. The Characteristics of the Market Welfare Impact

The size and sign of the market welfare impact of regulation in a revenue-supported industry depend on several key factors, notably the level of government support, the stringency of the regulation, and the characteristics of the market, i.e., the elasticities of average revenue and supply.

Consider first the impact of a general increase in government revenue support represented by a parallel upward shift in the AR curve in Figure 1. Obviously, such a shift will produce higher prices and quantities before and after regulation, thereby increasing both the positive area o and the negative area $e+i+n$. Because the vertical distance between average revenue and demand is greater at Q_1 than at Q_2 , the increase in o will exceed the increase in $e+i+n$ as long as Q_2 does not increase much more than Q_1 , which, as we show in Appendix A, will be the case as long as excess supply, $[S_i(Q_i) - AR(Q_i)]$, is not considerably more elastic at Q_2 than Q_1 . Since one could not expect the elasticity of excess supply to differ greatly before and

after regulation, one can conclude that, in general, an increase in government revenue support will decrease net market losses from regulation.

To examine the impact of an increase in regulatory stringency, i.e., the restrictions on production imposed by regulation, suppose that the post-regulation inverse supply curve, S_2 , shifts upward causing output to decline further (Q_2 decreases) and price to rise higher (P_1 increases). This shift in S_2 has two effects on the net market impact. On the one hand, the cost of producing postregulation output will increase as shown by an increase in the negative area $e+i+l+m+q+r$. On the other hand, the fall in output results in a decrease in postregulation deadweight less equal to the reduction in the $e+i+n$. As we show in Appendix A, unless the cost effect is quite small and/or excess supply is quite elastic, the cost effect will outweigh the output effect so that, in general, an increase in regulatory stringency will increase net market losses from regulation.

The impact of an increase in the elasticity of average revenue can be examined by considering a shift which flattens the average revenue curve around the initial market price and quantity, i.e., a rotation of AR around (P_1, Q_1) . It is easy to see from Figure 1 that this rotation of the AR curve reduces both P_2 and Q_2 , thereby reducing postregulation deadweight loss area $e+i+n$. As a result, one can conclude that an increase in the elasticity of average revenue will decrease net market losses from regulation.

The impact of an increase in the elasticity of supply can be examined by considering a similar rotation of the inverse supply curve around both the pre- and postregulation output levels, Q_1 and Q_2 . As is shown in Appendix A, if the shift in supply caused by regulation is relatively unaffected by the increase in the elasticity of supply, as would appear to be

reasonable, an increase in the elasticity of supply will decrease net market losses from regulation. The intuition here is straightforward. As long as the regulatory shift is relatively independent of the elasticity of supply, the increase in the cost of producing Q_2 caused by the regulation remains unaffected by changes in the elasticity of supply. However, the total cost of producing $Q_1 - Q_2$ prior to the new regulation will have increased which means that producers' preregulation profits will have been lower and hence new regulation will cause smaller losses.

C. The Specification Bias of the Standard Procedure

Welfare analyses are typically performed under the assumption that markets are in competitive equilibrium before and after regulatory measures are taken. When there are revenue-support programs effective in the industry in question, following this procedure means using a misspecified model; thus, standard methods can be expected to introduce specification biases into welfare estimates. The exact nature of the misspecification depends critically on the specific policy involved so that these biases can only be explored in the context of specific models. Thus, further discussion of this issue is relegated to the case of price supports examined below.

II. The Case of Agricultural Price Supports

Perhaps the most important examples of revenue-support programs are the price-support policies used in agriculture. The most important of these is the target-price scheme, which operates essentially as follows. Output is sold at the market price; when the market price falls below the target price, producers receive from the government a subsidy (known as the deficiency

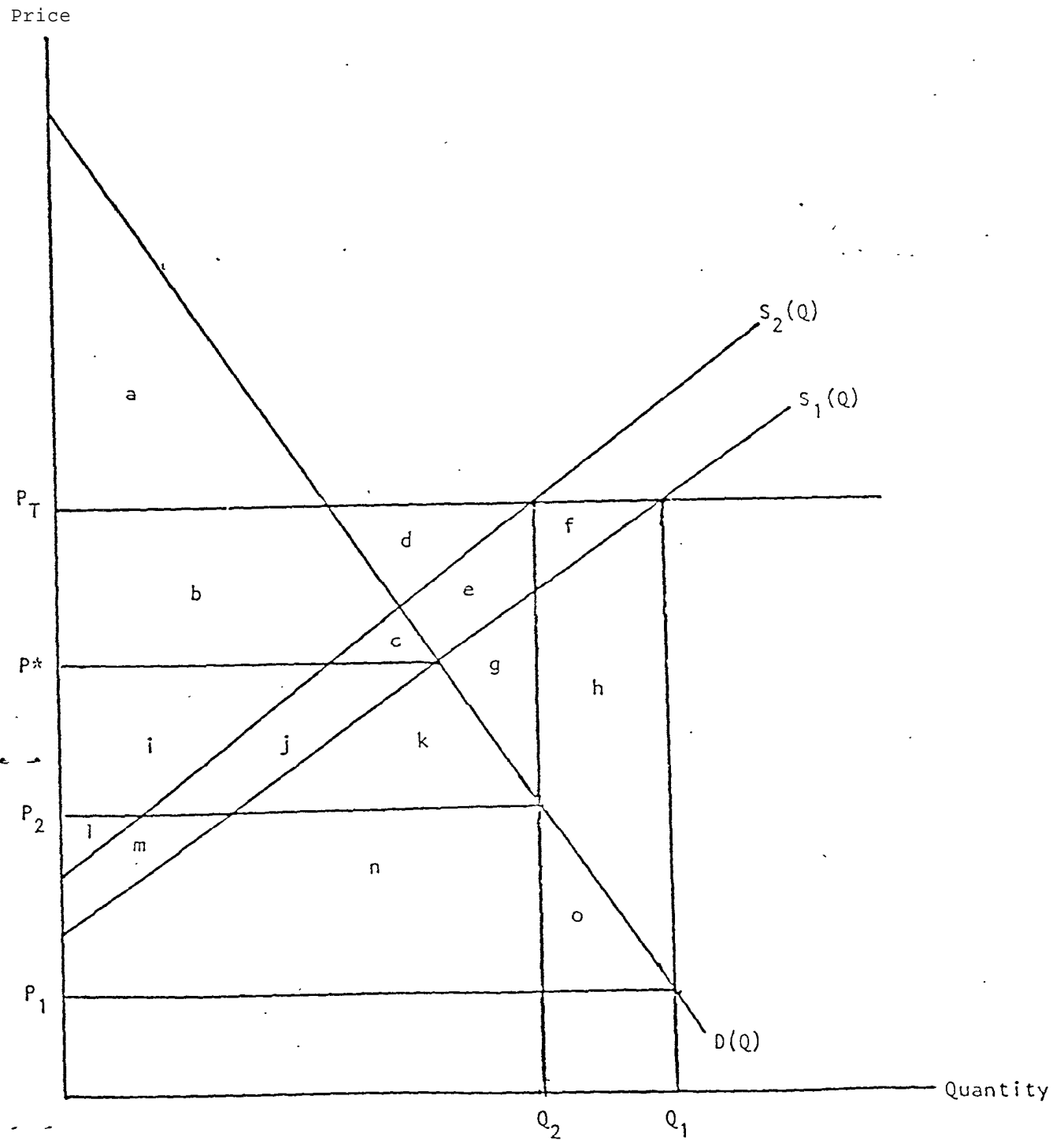
payment) equal to the difference between the two. When the competitive market-clearing price is below the target price, the target price becomes the effective price received by producers and thus the relevant price for production decisions, while output will be absorbed by consumers at a market price determined by the demand curve.³

This mechanism is illustrated in Figure 2. The target price is denoted by P_T , inverse supply by $S_1(Q)$, and inverse demand by $D(Q)$. Prior to the imposition of regulation farmers produce output, Q_1 , determined by the rule, $P_T = S_1(Q_1)$. The market price, P_1 , is determined by $P_1 = D(Q_1)$; and the government subsidy (or deficiency payment) is $P_T - P_1$ for each unit produced. Average revenue equals demand for prices greater than the target price and the target price thereafter. In this case, net consumer welfare can be decomposed into consumers' surplus and government expenditures; thus, it is possible to differentiate between the impact of regulation on consumer welfare narrowly construed and the impact on the U. S. Treasury costs of the price-support program.

Following T. D. Wallace (1962), Bruce Gardner (1983), and Richard E. Just (1985); the components of market welfare in this case are as shown in Figure 2. Let P^* denote competitive equilibrium price which would hold without the target price program before any input regulation. Consumers' surplus consists of the consumers' surplus under perfect competition (i.e., without intervention)-- $a+b+c$ plus government subsidized consumption $i+j+k+l+m+n+o$. Producers' surplus similarly consists of the perfect competition amount $(i+j+l+m)$ plus government transfer payments $(b+c+d+e+f)$. Government expenditures, $(P_T - P_1) Q_1$, consists of these transfer payments to consumers $(i+j+k+l+m+n+o)$ and producers $(b+c+d+e+f)$ plus a deadweight loss

Figure 2

Welfare Effects of Regulation in an Industry
With Price Supports



equal to $g+h$. Finally, total market welfare equals the standard competitive equilibrium surplus $(a+b+c+i+j+k+l+m)$ minus the deadweight loss $(g+h)$.

A. The Market Impact of Regulation

Suppose that the government imposes a new regulation on a market with price supports. As Figure 2 illustrates, the new regulation causes a leftward shift in the supply curve from $S_1(Q)$ to $S_2(Q)$ reducing output from Q_1 to Q_2 and raising the equilibrium price from P_1 to P_2 . By reducing output and increasing price, regulation causes a loss in consumers' surplus equal to the area $l+m+n+o$ and a loss in producers' surplus equal to the area $c+e+f+j+m$, while U. S. Treasury costs decrease by an amount equal to the area $f+h+l+m+n+o$. One part of the savings in government expenditure, $l+m+n+o$, exactly matches the loss in consumers' surplus. Because this part of consumption is entirely subsidized, the aggregate consumer loss exactly matches the savings to the taxpayers. Similarly, another part of government savings, f , matches part of the loss in producers' surplus; this, too, is a reduction in subsidization which has no net effect on social welfare. Thus, the net change in social welfare is $h - (c+e+j+m)$.

As before, one can also interpret this market welfare effect in terms of the impact of regulation on social efficiency. It is clear from Figure 2 that the area $c+j+m$ represents the social loss due to the increased cost of producing the competitive equilibrium quantities before and after regulation. In other words, $c+j+m$ represents the net economic cost of regulation in competitive equilibrium. When government subsidies are present, regulation causes an additional effect, namely, a reduction in deadweight loss from $g+h$ to $e+g$, a net change of $h-e$. Thus, $h-e-c-j-m$ represents the changes on the social efficiency of production caused by regulation.

Unlike the general case under price supports, the net effect of regulation on consumers in their dual role of consumers/taxpayers is always positive while the effect on producers is always negative. It is thus evident that the distribution of gains and losses from regulation under price supports will be the exact opposite of the situation under competitive equilibrium; hence, price supports will strengthen producers' opposition to regulation and consumers' support for regulation.

The size and sign of the market welfare effect of regulation in a price-supported industry depend on the target price, the stringency of the regulation, and the elasticities of supply and demand. It is not hard to modify the results given in Appendix A to show that (1) an increase in the target price will decrease net market losses from regulation, (2) an increase in regulatory stringency will increase net market losses from regulation, (3) an increase in the elasticity of demand will decrease net market losses from regulation, and (4) an increase in elasticity of supply will decrease net market losses from regulation.

B. The Specification Bias of the Standard Procedure

Welfare analyses are typically performed under the assumption that markets are in competitive equilibrium before and after regulatory measures are taken. When the industry in question has effective price supports, following this procedure means using a misspecified model, and the standard methods can be expected to introduce specification biases into welfare estimates. This section examines the characteristics of these biases. Since demand is not affected by target prices, it will be assumed that the true inverse demand curve, $D(Q)$, is used. The estimated inverse supply curve, $\hat{S}_1(Q)$, will be

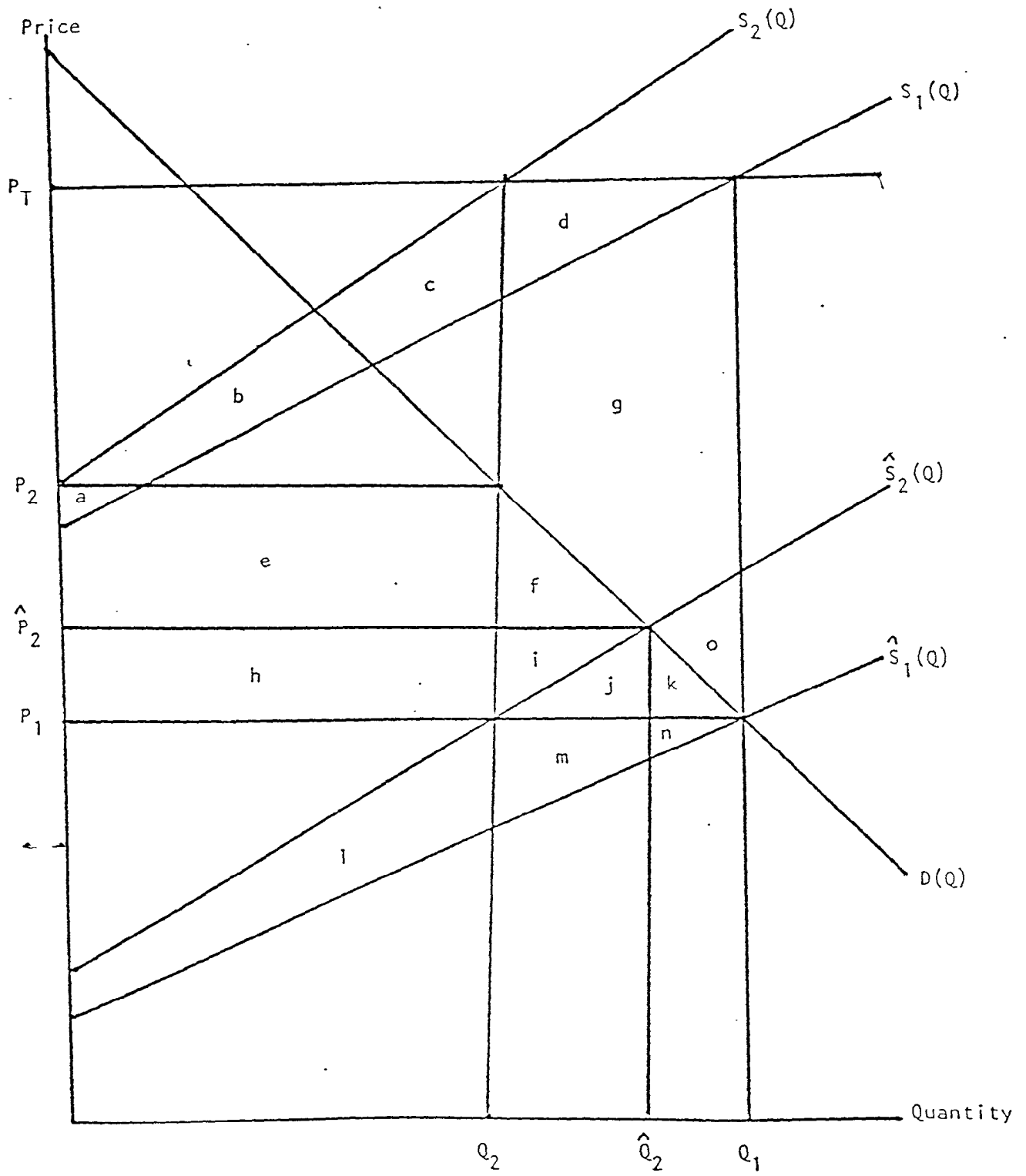
formed by shifting the true curve, $S_1(Q)$, downward sufficiently to intersect the inverse demand curve at (P_1, Q_1) . An illustration of the relationship between the estimated and true models is given in Figure 3.

Consider first the estimate of the loss in consumers' surplus generated by the standard model. Let $\hat{S}_2(Q)$, \hat{Q}_2 , and \hat{P}_2 denote estimated post-regulation inverse supply, predicted output, and predicted price, respectively. As one can see from Figure 3, the true loss in consumers' surplus is $a+e+f+h+i+j+k$ while the estimated loss is only $h+i+j+k$, leaving $a+e+f$ as the specification bias of the standard procedure. (An algebraic derivation is given in Appendix B.) Thus, the standard method underestimates consumer losses from regulation. Intuitively, because equilibrium output is determined by movements along the demand curve in the misspecified model, the impact of new regulation on output and price is always underestimated: The predicted quantity is larger and the predicted price lower than will actually be the case. As a result, consumers' losses are underestimated as well.

As one can see from Figure 3, the estimated loss in producers' surplus equals the increased cost of producing \hat{Q}_2 less the revenue gain due to the estimated increase in price from P_1 to \hat{P}_2 and is thus equal to the area $l+m+n - (h+l)$. The true loss in producers' surplus, of course, equals the area $a+b+c+d$. In Figure 3 the estimated pre- and postregulation supply curves, S_1 and S_2 , are assumed to be parallel to their true counterparts. When this assumption holds, $l+m+n = a+b+c+d$; and the true loss in producers' surplus exceeds the estimated loss by an amount equal to $h+i$. In Appendix B it is shown that the estimated loss to producers will exceed the true loss only when the estimated preregulation supply curve is considerably steeper

Figure 3

Specification Bias of the Competitive Equilibrium Assumption



than its true counterpart. In general, then, one can conclude that the standard method underestimates producer losses from regulation.

In competitive equilibrium, regulation always causes a net loss in social welfare, i.e., the net market effect of regulation is always negative. In Figure 3 the estimated market welfare effect is thus the negative area $j+k+l+m+n$. However, the true market welfare effect is the area $g+o - (a+b+c)$. Since $a+b+c+d = l+m+n$ in this case, the estimated market welfare effect exceeds the true market welfare effect by an amount equal to the area $d+g+o+j+k$. In Appendix B, it is demonstrated that the estimated market welfare loss always exceeds the true value, i.e., that the standard method overestimates net market losses from regulation. This bias arises because the standard method ignores the positive impact of reductions in government revenue support program payments on market welfare. As it turns out, these reductions are always large enough to outweigh the biases in the estimation of consumers' and producers' losses.

In sum, the standard procedure of assuming competitive equilibrium will always produce biased estimates of the welfare effects of secondary regulation in a revenue-supported industry. In particular, the standard procedure overestimates the market welfare impact of regulation and can thus be said to be biased against regulation. It follows that the market welfare effect of regulation will be smaller than that estimated, so that regulation is more desirable than standard analyses indicate.

C. Empirical Examples

The price-support form of government subsidization is found most commonly in agriculture; thus, one would expect agriculture to provide good examples of the impact of price-support programs on the net market effect of regulation,

on the distribution of costs between producers and consumers, and on the specification bias caused by an erroneous assumption of a competitive equilibrium framework.

This section uses the case of a regulations-restricting production of the five most important U. S. crops (corn, cotton, rice, sorghum, and wheat) covered by effective price supports to illustrate these effects. It was assumed that the elasticities of supply and demand were constant for all five crops so that the inverse demand for each crop, $D(Q)$, had the form $a_0 Q^{b_1}$ and the inverse supply before regulation, $S_1(Q)$, had the form $b_0 Q^{b_1}$ and that the ban on the pesticide decreased supply by t percent so that the inverse supply after regulation, $S_2(Q)$, had the form $(1+t)b_0 Q^{b_1}$. Estimates of the elasticities of supply and demand were taken from a number of sources; both the estimates and their sources are shown in Table 1. Estimates of output target prices and market prices, also shown in Table 1, were chosen to be broadly representative of the levels prevailing in recent years (see U. S. Department of Agriculture, 1983). The parameters a_0 and b_0 were chosen to equate inverse demand with the market price and inverse supply with the target price at current output levels. The inverse supply curve, $\hat{S}_1(Q)$, estimated under the assumption of competitive equilibrium prior to the pesticide ban, was formed by choosing the parameter \hat{b}_0 to equate inverse supply with the market price at current output levels. The regulations were assumed to decrease the supply of these crops by 1 percent (a figure which appears to be not atypical of pesticide bans; see, for instance, National Academy of Sciences, 1983). The model was then used to calculate the welfare effects of the ban with and without price supports and the welfare effects estimated

TABLE 1
Model Parameters

Crop	Elasticity of supply	Elasticity of demand	Output (billion bushels)	Market price (dollars/bushel)	Target price (dollars/bushel)
Corn	.30	-.50	8.00	2.50	3.00
Cotton ^a	.50	-.41	12.00	.80	.60
Rice ^b	.80	-.43	.15	9.00	11.90
Sorghum	.71	-.83	.85	2.40	2.90
Wheat	.30	-.99	2.50	4.40	3.40

^aOutput measured in bales and price in dollars per pound.

^bQuantities measured in hundredweight.

Sources: Rice supply, Collins and Evans; sorghum supply, Gallagher and Green; corn and wheat supply and demand, Gardner (1984); rice demand, Grant, Beach, and Lin; sorghum demand, Grant and Hoskin; cotton demand, Townsend; cotton supply, Townsend Skelly, and Sronce; quantities, market prices, and target prices, U. S. Department of Agriculture.

under an incorrect assumption of competitive equilibrium when price supports were present.

The results of this procedure, shown in Table 2, demonstrate that (1) savings in U. S. Treasury costs from regulation are quite substantial, (2) price supports cause sizable changes in the welfare effects of regulation, (3) regulation will have no net market effect for target prices not too much greater than those currently in force, and (4) treating the behavior observed under price supports as if it were generated by competitive equilibrium leads to substantial overestimation of the net market effect of regulation.

First, note that the savings in U. S. Treasury costs associated with regulation are quite high for all of these crops. At current target price levels, for example, the ratio of government savings to the sum of producers' and consumers' losses ranges from a low of .65 for wheat, to about .75 for corn and sorghum, and to roughly .85 for cotton and rice. Consequently, it is apparent that ignoring this component of market welfare will lead to serious distortions in evaluating policy alternatives.

Second, compare the welfare effects of regulation in competitive equilibrium with those with target prices at current levels. In competitive equilibrium, producers gain from the ban in every case and substantially so in the cases of corn (\$30 million), cotton (\$17 million), and rice (\$3 million). As a result, one would expect members of this group (or at least some sections of it) to support regulation. Consumers, on the other hand, sustain substantial losses from the ban in every case--\$10 million for rice and sorghum, \$20 million for wheat, \$43 million for cotton, and \$77 million for corn. (In the case of pesticides, for example, one would thus expect only the more environmentally minded members of this group to support regulation.)

TABLE 2
Welfare Effects of a Pesticide Ban

	ΔCS	$\Delta \hat{CS}$	ΔPS	$\Delta \hat{PS}$	ΔGP	$\Delta CS - \Delta GP$	ΔW	$\Delta \hat{W}$
	(million dollars)							
CORN								
Competitive equilibrium	- 77.30		29.73				-47.57	
Target price (dollars per bushel)								
3.00 ^a	-119.58	-74.70	- 55.03	28.73	-131.33	11.74	-43.28	-45.97
3.50	-114.18	-71.32	- 67.24	29.13	-144.50	30.32	36.92	-46.19
4.00	-109.69	-68.52	- 79.98	21.73	-158.82	49.13	-30.85	-47.79
4.50	-105.89	-66.14	- 93.22	18.47	-174.13	68.24	-24.98	-47.67
5.00	-102.59	-64.09	-106.90	15.30	-190.26	87.67	-19.23	-48.78
5.50	- 99.70	-62.28	-121.00	12.19	-207.15	107.45	-13.55	-50.09
6.00	- 97.13	-60.67	-135.49	9.11	-224.71	127.58	- 7.92	-51.56
6.50	- 94.83	-59.23	-150.35	6.07	-242.87	148.04	- 2.31	-53.17
COTTON								
Competitive equilibrium	- 43.28		17.02				-26.26	
Target price (dollars per pound)								
0.80 ^a	- 87.68	-39.43	- 31.76	15.51	- 99.38	11.69	-20.07	-23.92
0.90	- 80.56	-36.22	- 37.90	12.12	-104.38	23.82	-14.08	-24.10
1.00	- 74.68	-33.58	- 44.39	8.97	-110.64	35.97	- 8.42	-24.60
1.10	- 69.73	-31.35	- 51.21	6.00	-117.96	48.23	- 2.98	-25.36
1.20	- 65.50	-29.45	- 58.35	3.13	-126.17	60.67	2.32	-26.32
1.30	- 61.83	-27.80	- 65.79	0.34	-135.17	73.34	7.55	-27.46
1.40	- 58.62	-26.36	- 73.53	- 2.40	-144.88	86.26	12.73	-28.76
1.50	- 55.78	-25.08	- 81.55	- 5.11	-155.24	99.45	17.91	-30.19
RICE								
Competitive equilibrium	- 9.71		3.07				- 6.63	
Target price (dollars per hundredweight)								
11.90 ^a	- 25.12	- 8.75	- 7.86	2.77	- 28.47	3.35	- 4.51	- 5.98
12.30	- 24.26	- 8.45	- 8.34	2.46	- 28.85	4.59	- 3.76	- 5.99
12.70	- 23.45	- 8.17	- 8.84	2.16	- 29.28	5.83	- 3.01	- 6.01
23.10	- 22.69	- 7.91	- 9.34	1.87	- 29.76	7.07	- 2.28	- 6.04
13.50	- 21.98	- 7.66	- 9.87	1.58	- 30.29	8.31	- 1.56	- 6.08
13.90	- 21.31	- 7.42	-10.40	1.30	- 30.85	9.56	- 0.84	- 6.12
14.30	- 20.68	- 7.20	-10.94	1.02	- 31.49	10.81	- 0.14	- 6.18
14.70	- 20.08	- 7.00	-11.50	0.74	- 32.15	12.07	0.57	- 6.25
SORGHUM								
Competitive equilibrium	- 9.50		0.94				- 8.56	
Target price (dollars per bushel)								
2.90 ^a	- 17.38	- 9.36	- 10.15	0.93	- 20.31	2.93	- 7.22	- 8.43
3.10	- 17.21	- 9.27	- 11.37	0.84	- 22.38	5.17	- 6.21	- 8.44
3.30	- 17.05	- 9.19	- 12.66	0.74	- 24.54	7.49	- 5.17	- 8.45
3.50	- 16.91	- 9.11	- 14.00	0.64	- 26.81	9.90	- 4.10	- 8.47
3.70	- 16.77	- 9.04	- 15.39	0.53	- 29.17	12.40	- 2.99	- 8.50
3.90	- 16.64	- 8.97	- 16.84	0.43	- 31.63	14.99	- 1.86	- 8.50
4.10	- 16.52	- 8.90	- 18.35	0.32	- 34.18	17.66	- 0.69	- 8.58
4.30	- 16.41	- 8.84	- 19.90	0.21	- 36.82	20.41	0.51	- 8.65

(Continued on next page.)

TABLE 2--continued.

	ΔCS	$\Delta \hat{CS}$	ΔPS	$\Delta \hat{PS}$	ΔGP	$\Delta CS - \Delta GP$	ΔW	$\Delta \hat{W}$
	(million dollars)							
WHEAT								
<u>Competitive equilibrium</u>	- 19.69		0.15				-19.54	
<u>Target price (dollars</u>								
<u>per bushel)</u>								
4.40 ^a	- 25.62	-19.69	- 25.22	0.15	- 33.04	7.42	-17.80	-19.54
4.90	- 25.62	-19.69	- 29.01	0.14	- 37.97	12.35	-16.66	-19.54
5.40	- 25.62	-19.69	- 32.91	0.14	- 43.04	17.43	-15.49	-19.49
5.90	- 25.62	-19.64	- 36.93	0.13	- 48.27	22.65	-14.28	-19.52
6.40	- 25.62	-19.64	- 41.05	0.12	- 53.62	28.00	-13.05	-19.52
6.90	- 25.57	-19.64	- 45.27	0.12	- 59.10	33.53	-11.74	-19.52
7.40	- 25.57	-19.64	- 49.58	0.11	- 64.71	39.14	-10.44	-19.53
7.90	- 25.57	-19.64	- 53.97	0.10	- 70.42	44.86	- 9.12	-19.54

^aDenotes current target price.

With price supports, the situation is reversed: Consumers in their dual role as consumers/taxpayers benefit unambiguously--and considerably--to the tune of \$3 million for rice and sorghum, \$7 million for wheat, and \$12 million for corn and cotton and can thus be expected to support regulation more wholeheartedly, while producers suffer rather large losses--about \$8 million for rice, \$10 million for sorghum, \$25 million for wheat, \$32 million for cotton, and \$55 million for corn. One can thus target agricultural policy as a key determinant of the political-economic conditions affecting environmental regulation in agriculture, in particular, the entrenchment of farmers' opposition to this type of intervention.

The third point of interest is that, for several crops (cotton, rice, and sorghum), regulation will have no net market effect at target prices not much greater than those currently in effect. For cotton, the zero-impact target price is only 37 cents per pound (about 45 percent) higher than the current target price; for sorghum, it is only \$1.32 per bushel (about 45 percent) higher; and for rice, only \$2.48 per hundredweight (about 20 percent) higher. One can see that the net market effect of regulation is both lower and declines more rapidly as supply becomes more elastic. For example, corn, cotton, and rice have roughly the same elasticities of demand (.4 to .5), while rice has a supply elasticity nearly twice that of cotton which has a higher supply elasticity of nearly twice that of corn. Correspondingly, the proportional increase in the target price of rice required to produce a zero net market impact from the ban is only about one-half that required for cotton and only about one-sixth that required for corn. Finally, sorghum and wheat have roughly the same demand elasticities, while sorghum has an elasticity of supply over twice that of wheat and requires only one-third of the

proportional increase in target price to reach a zero net market impact. The impact of demand elasticity is less straightforward since a high elasticity of demand reduces both the net market effect and the rate of decline with respect to the target price. For example, wheat has the same elasticity of supply as corn but an elasticity of demand about twice as large. The net market impact of regulation on wheat is, correspondingly, only one-half of that for corn at current target prices; the proportionate increase in target price required to attain a zero net market impact for wheat is, nevertheless, higher than that for corn.

The implication of these results is that environmental regulation becomes more attractive as government subsidization of agriculture grows, especially in markets where supply is less inelastic. This is particularly important for crops such as cotton and rice which are among the largest users of inputs implicated in many environmental and resource problems (e.g., water and pesticides); for these crops, relatively small increases in subsidies serve to eradicate market losses from environmental regulation.

Finally, it is evident that treating markets with price supports as if they are in competitive equilibrium leads to significant overestimation of the net economic costs of the pesticide ban. It is instructive to note that the welfare effects estimated using the true inverse supply curve under a competitive equilibrium assumption (the "textbook model") and those estimated using the inverse supply curve estimated under the assumption of competitive equilibrium as described in Section II (the "estimated model") are essentially identical, so that either model can be said to give an accurate description of the welfare effects of regulation in competitive equilibrium. In every case net market losses from regulation in competitive equilibrium are substantially

higher than net market losses at current target price levels--about 10 percent higher for corn and wheat, 20 percent higher for sorghum, over 30 percent higher for cotton and almost 50 percent higher for rice in the textbook model and 6 percent higher for corn, 10 percent higher for wheat, close to 20 percent higher for sorghum and cotton, and about 33 percent higher for rice in the estimated model. The size of the bias clearly increases as the elasticity of supply increases since it is small for the most inelastic crops (corn and wheat), larger for the less inelastic (sorghum and cotton), and largest for the least inelastic (rice). A larger elasticity of demand appears to have contradictory effects on the size of the bias since sorghum has more elastic supply and demand for cotton yet a higher elasticity of demand than corn and a slightly higher bias.

These results imply that the use of a competitive equilibrium framework may introduce serious errors into regulatory welfare analyses, errors which may well be sufficiently serious to bring about significant alterations in regulatory policy. Producers whose supply is less inelastic are of particular concern in this regard. Thus, these errors were relatively small for corn and wheat, crops whose supplies are rather inelastic, and quite large--on the order of one-third to one-half of the true net market impacts--for more elastic crops such as cotton and rice.

This analysis has some interesting implications for pesticide regulation in particular. Crops such as cotton and rice number among the largest users of pesticides and, hence, among the crops most affected by pesticide regulation. The analysis suggests that the regulatory welfare analyses performed up until the present have overstated the net market impact of pesticide regulation by a significant margin (e.g., 30 percent for cotton and

50 percent for rice) and hence that the EPA should be regulating many pesticides much more stringently than has been its practice.

III. Conclusion

Government regulation has become sufficiently pervasive that new regulations are impinging on preexisting policies to an increasing extent. Evaluations of the market effects of newer regulations must, therefore, take account of these prior regulations. This paper has developed a framework for analyzing the market welfare effects of regulation for the case of a pre-existing regime of revenue-support programs. To facilitate the analysis, several simplifications were made. First, many revenue-support programs have specific secondary features which were ignored, for example, the set-aside requirements of agricultural price-support programs. Second, regulation may influence prior policies so that their true impact on the market is dynamic. For example, environmental regulation in agriculture may increase production costs and thereby induce increases in target prices since the latter are pegged to costs. The framework developed here treated policies in a static Cournot-Nash way; a more complete analysis would address these feedback effects. Nevertheless, the presence of these prior policies was shown to cause striking alterations in the welfare effects of new regulations; in addition, these changes were significant enough both qualitatively and quantitatively to indicate that ignoring prior policies introduces serious distortions into regulatory welfare analyses.

The theoretical portion of the paper showed first that the distribution of the welfare effects of regulation under revenue supports tends to be opposite of that under competitive equilibrium: Under revenue supports, producers tend

to lose and consumers tend to gain whereas, under competitive equilibrium, consumers always lose and producers may gain, especially in industries facing inelastic demand as revenue-supported industries tend to be. Second, under revenue supports, regulation may have no net effect on market welfare and may even result in gains in social welfare. Market welfare losses from regulation is shown to be smaller with higher revenue support, more elastic supply and average revenue, and less stringent regulation. Third, treating markets with revenue supports as if they were in competitive equilibrium produces biased estimates of the welfare effects of new regulation: In the price support case, the costs to consumers and producers are underestimated; but the market welfare effect is overestimated, making regulation seem less desirable than it actually is.

The framework was then applied to the case of regulations affecting the five most important agricultural commodities with effective support programs: corn, cotton, rice, sorghum, and wheat. The savings in U. S. Treasury costs turned out to be rather large relative to consumers' and producers' losses. Price supports were shown to have large effects on the distribution of costs in the majority of cases turning significant gains for producers into sizable losses and sizable losses to consumers into noticeable gains. For the majority of crops, the target price at which regulation had zero market welfare impact turned out to be not too much higher than the levels currently in effect. Finally, the use of a competitive equilibrium framework was shown to introduce significant biases into estimates of the market welfare effects of regulation: for some crops, the upward bias was on the order of one-third to one-half of the actual market welfare effect.

It should be noted that this analysis was conducted from the point of view of economic efficiency and that these results were derived on the basis of

efficiency considerations alone. While important, efficiency is not the only factor affecting regulatory decisions; for example, the redistribution of income inherent in revenue-support programs may have some explicit social utility or may arise from rent-seeking behavior or other political factors. The impact of regulation in revenue-supported industries on equity and political economic considerations is thus also an area of considerable interest and deserves further investigation.

APPENDIX A

This Appendix provides algebraic derivations of the impacts of various factors on the net economic cost of regulation. In the general case, the equilibrium market prices before and after regulation are determined by the relation:

$$(A1) \quad AR(Q_i) = S_i(Q_i), \quad i = 1, 2.$$

Consumers' surplus before and after regulation is:

$$(A2) \quad CS_i = \int_0^{Q_i} D(Q) dQ - P_i Q_i, \quad i = 1, 2$$

so that the effect of regulation on consumers is:

$$(A3) \quad \Delta CS = CS_2 - CS_1 = P_1 Q_1 - P_2 Q_2 - \int_{Q_2}^{Q_1} D(Q) dQ.$$

Producers' surplus before and after regulation is:

$$(A4) \quad PS_i = P_i Q_i - \int_0^{Q_i} S_i(Q) dQ, \quad i = 1, 2,$$

so that the effect of regulation on producers is:

$$(A5) \quad \Delta PS = P_2 Q_2 - P_1 Q_1 - \int_0^{Q_2} [S_2(Q) - S_1(Q)] dQ + \int_{Q_2}^{Q_1} S_1(Q) dQ.$$

Finally, the effect of regulation on total welfare, that is, the net economic cost of regulation, is the sum of (A3) and (A5):

$$(A6) \quad \Delta W = \int_{Q_2}^{Q_1} [S_1(Q) - D(Q)] dQ - \int_0^{Q_2} [S_2(Q) - S_1(Q)] dQ.$$

To explore the impact of a general increase in government revenue support on the net market effect, rewrite the average revenue curve as an increasing function of Q and a policy shifter z , $AR(Q, z)$, where larger values of z represent increases in government support. From (A6), it is evident that:

$$(A7) \quad \frac{\partial \Delta W}{\partial z} = [P_1 - D(Q_1)] \frac{\partial Q_1}{\partial z} - [P_2 - D(Q_2)] \frac{\partial Q_2}{\partial z}.$$

For the case of a parallel shift in the average revenue curve, $\partial AR / \partial Q = k$ for all Q ; this can be rewritten using (A1) as:

$$(A8) \quad \frac{\partial \Delta W}{\partial z} = k[(1 - r_1) Q_1 e(Q_1) - (1 - r_2) Q_2 e(Q_2)]$$

where $r_i = D(Q_i)/P_i$, the ratio of demand price to market price; and $e(Q_i)$ represents the elasticity of excess supply at Q_i , $S_i(Q_i) - AR(Q_i)$. Obviously, $\partial \Delta W / \partial z < 0$ only when $e(Q_2)/e(Q_1) > (1 - r_1) Q_1 / (1 - r_2) Q_2 > 1$.

To explore the impact of changes in regulatory stringency on the net market effect, let $S_2(Q) - S_1(Q) = T(Q, t)$ where t is a parameter which increases the size of the shift, i.e., $\partial T / (\partial t) > 0$. Increased stringency will be taken to mean a larger regulatory shift, i.e., an increase in t . Using (A6) and (A1), it is straightforward to show that:

$$\begin{aligned}
(A9) \quad \frac{\partial \Delta W}{\partial t} &= -[P_2 - D(Q_2)] \frac{\partial Q_2}{\partial t} - \int_0^{Q_2} \frac{\partial T(Q, t)}{\partial t} dQ \\
&= (1 - r_2) Q_2 e(Q_2) \frac{\partial T(Q_2)}{\partial t} - \int_0^{Q_2} \frac{\partial T(Q, t)}{\partial t} dQ.
\end{aligned}$$

Unless $e(Q_2)$ is relatively large or $\int_0^{Q_2} \partial T(Q, t)/(\partial t) dQ$ is quite small, $\partial \Delta W/(\partial t) < 0$.

To derive the impact of an increase in the elasticity of demand, let $\partial AR/(\partial z) \stackrel{>}{\leq} 0$ as $Q \stackrel{>}{\leq} Q_1$ so that (A7) becomes:

$$(A10) \quad \frac{\partial \Delta W}{\partial z} = -[P_2 - D(Q_2)] \frac{\partial Q_2}{\partial z} > 0.$$

Similarly, the effect of an increase in the elasticity of supply can be derived by rewriting S_i as a function of a shifter n such that $\partial S_i/(\partial n) \stackrel{>}{\leq} 0$ as $Q \stackrel{\leq}{>} Q_1$. It follows that

$$(A11) \quad \frac{\partial \Delta W}{\partial n} = \int_{Q_2}^{Q_1} \frac{\partial S_1(Q, n)}{\partial n} dQ - \int_0^{Q_2} \frac{\partial T(Q, t, n)}{\partial n} dQ$$

which is positive whenever $\partial T/(\partial n) = 0$, as one would expect to be the case.

APPENDIX B

This Appendix derives the specification biases introduced into welfare estimates by the application of a competitive equilibrium model to a market with a target price program. Output before and after regulation is determined by the relation:

$$(B1) \quad P_T = S_i(Q_i)$$

while market price is determined by:

$$(B2) \quad P_i = D(Q_i).$$

Since demand is not affected by target prices, it will be assumed that the true inverse demand curve $D(Q)$ is used. The estimated inverse supply curve, $\hat{S}_1(Q)$, will be formed by shifting the true curve, $\hat{S}(Q)$, downward sufficiently to intersect the inverse demand curve at (P_1, Q_1) . Represent this shift by an arbitrary function $R(Q) > 0$ so that:

$$(B3) \quad \hat{S}_1(Q) = S_1(Q) - R(Q).$$

Consider first the estimate of the loss in consumers' surplus generated by the standard model. Letting $\hat{S}_2(Q)$, \hat{Q}_2 , and \hat{P}_2 denote postregulation inverse supply, predicted output, and predicted price, respectively, it is straightforward to show that the estimated change in consumers' surplus, $\Delta\hat{CS}$, is related to the true change in consumers' surplus by

$$(B4) \quad \Delta\hat{CS} = \Delta CS + (P_2 + \hat{P}_2) Q_2 + \int_{Q_2}^{Q_2} [D(Q) - P_2] dQ.$$

Since $D(Q) > P_2$ for $Q < Q_2$, it is evident that $\Delta CS > \Delta CS$, **that** is, that the standard method underestimates consumer losses from new regulation.

It is similarly straightforward to **show** that the estimated change in producers' surplus is related to the actual change by

$$(B5) \quad \Delta PS = \Delta PS + \int_{Q_2}^{\hat{Q}_2} [P_2 - S_2(Q)] dQ + (P_2 - P_1) Q_2 \\ + \int_{Q_2}^{Q_1} [P_T - P_1 - R(Q)] dQ.$$

It is obvious that $P_2 > S_2(Q)$ for $Q < Q_2$ and that $P_2 > P_1$ so that the second two terms on the right-hand side of (B5) are both positive. The final term represents an additional adjustment for the nature of the shift from the true supply curve to the estimated curve. If the shift is parallel, $R(Q) = P_T - P_1$ for all Q and the final term is zero. Insofar as the shift is more (less) than parallel, the final term is negative (positive). In general, one would expect this term to be small relative to the other two. Thus, one can conclude that the standard method tends to underestimate producer losses from new regulation even though it remains possible that the standard method will overestimate the cost of new regulation to producers.

Finally, using the standard relation, $\Delta W = \Delta PS + \Delta CS$, one obtains

$$(B6) \quad \hat{\Delta W} = \Delta W + \int_{Q_2}^{Q_2} [D(Q) - S_2(Q)] dQ - \int_{Q_2}^{Q_1} R(Q) dQ.$$

Since $D(Q) < S_2(Q)$ in the relevant range and $R(Q) > 0$ everywhere, the second and third terms on the right-hand side are both negative. Thus, $\hat{\Delta W} < \Delta W$, and the standard method overestimates the net economic cost of secondary regulation.

FOOTNOTES

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²No welfare connotations will be attached to the area between the average revenue and demand curves. This area may reflect the social benefits of redistributing income to producers or may equally be the result of producers' rent-seeking behavior. This analysis follows traditional welfare theory which emphasizes efficiency considerations and will, thus, exclude any explicit evaluation of these factors.

³The analysis presented in this paper is based on three major simplifications of the actual target price program. First, farmers receive deficiency payments based not on actual yields but on a percentage of historic average yields so that the effective target price differs from the nominal target price. Incorporating this feature involves some additional computations but alters nothing essential in the analysis. Second, to qualify for deficiency payments, farmers must remove (set aside) certain proportions of their land from productive use. These set-asides alter input use and, hence, the shape of the supply curve. Finally, target prices are based on a moving average of production costs. Any regulation which increases costs will, thus, increase target prices in several subsequent years so that a complete analysis of its market welfare impacts will necessarily be dynamic. Incorporation of these aspects is beyond the scope of this paper and will be addressed in further work.

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C. HETEROGENEOUS PRODUCTION AND THE POLITICAL
ECONOMY OF REGULATION

Economics has been playing an increasingly prominent role in the regulatory process as a means of evaluating the impacts of alternative policy measures. The standard procedures for making these economic evaluations are those of the New Welfare Economics based on the compensation principle and employing aggregate supply and demand relations. They focus chiefly on overall economic efficiency and on intersectoral redistributions, that is, redistributions between producers and consumers in the aggregate.

The implicit assumption of this approach is that industries are homogeneous (or very nearly so), so that intraindustry redistributions are negligible. But in reality, the firms in an industry may differ considerably: firms may differ in the vintages of capital they employ and thus in technology; there may be pronounced regional differences in resource endowments and hence productivity; etc. Thus the effects of regulation may vary substantially across classes of firms, conceivably enough so that the intraindustry effects could be more marked than the intersectoral ones.

These intraindustry effects are especially important because of their political-economic ramifications. As the recent literature on this subject (Stigler (1971), Peltzman (1976)) has pointed out, the actual shape assumed by regulatory programs depends largely on the relative strengths of the coalitions supporting and opposing various forms of regulation; these

coalitions, in turn, are formed largely on the basis of who gains and who loses from prospective regulatory measures. For this reason, information about the sizes of the gains and losses sustained under alternative regulatory options by the chief subgroups of gainers and losers is very much in demand among those in the legislative and executive branches charged with setting regulatory policy. For example, the choice of a regulatory program may hinge on how the available alternatives affect smaller versus larger firms or how they affect producers in different regions, while impacts on consumers may be of little or no concern. The information on the intersectoral effects of regulation provided by the standard aggregate welfare framework thus tends to be inadequate for actual regulatory purposes.

It is important to realize also that both the intraindustry and intersectoral effects of regulation may be influenced to a considerable extent by other factors operating on the markets affected by proposed regulations, for example, trade conditions or previously imposed policies. The influence of such factors may be sufficiently great to alter qualitatively the political-economic ramifications of proposed regulatory measures. For example, regulations which producers favor when the dollar is weak may become totally unacceptable to them as trade conditions worsen. From a regulatory point of view, then, it is crucial to incorporate the overall economic environment into the framework used to assess the welfare impacts of regulatory alternatives.

This paper explores the implications of producer heterogeneity and of shifting economic environments

(specifically, trade conditions and some common forms of prior regulations) on the political economy of regulation. The initial sections treat these issues briefly using a simple analytic framework. The major part of the paper is then devoted to an empirical example of regulation affecting the U.S. cotton industry. To permit easier assessment of regulatory welfare effects, we develop two new measures, the supply and welfare cross-elasticities of regulatory response, which we use to compare the intersectoral and intraindustry effects of regulations imposed on different cotton-producing regions under alternative exchange rate scenarios.

Intraindustry Effects of Regulation

For simplicity, consider the case (depicted in Figure 1) of a good produced by an industry containing two classes of firms. Class 1 firms, the lower cost firms, will produce positive output whenever the price is at least P_1 ; their supply curve is depicted by S_1 . Class 2 firms, the high cost firms, will produce only when the price is at least $P_2 > P_1$; their supply is S_2 . Aggregate supply is simply the sum of the supplies of the two classes of firms; it thus consists of S for prices $P_1 \leq P < P_2$ and $S_1 + S_2$ for prices $P \geq P_2$, i.e., it is the envelope of the supply curves S_1 and $S_1 + S_2$ shown in Figure 1.

Suppose that a regulation is imposed which increases the production costs of Class 1 firms, increasing the minimum supply price to P_1' and shifting supply to S_1' , but which has no effect on Class 2 firms. Aggregate supply will decrease to S_1' for prices $P_1' \leq P < P_2$ and $S_1' + S_2$ for prices $P \geq P_2$. If demand is

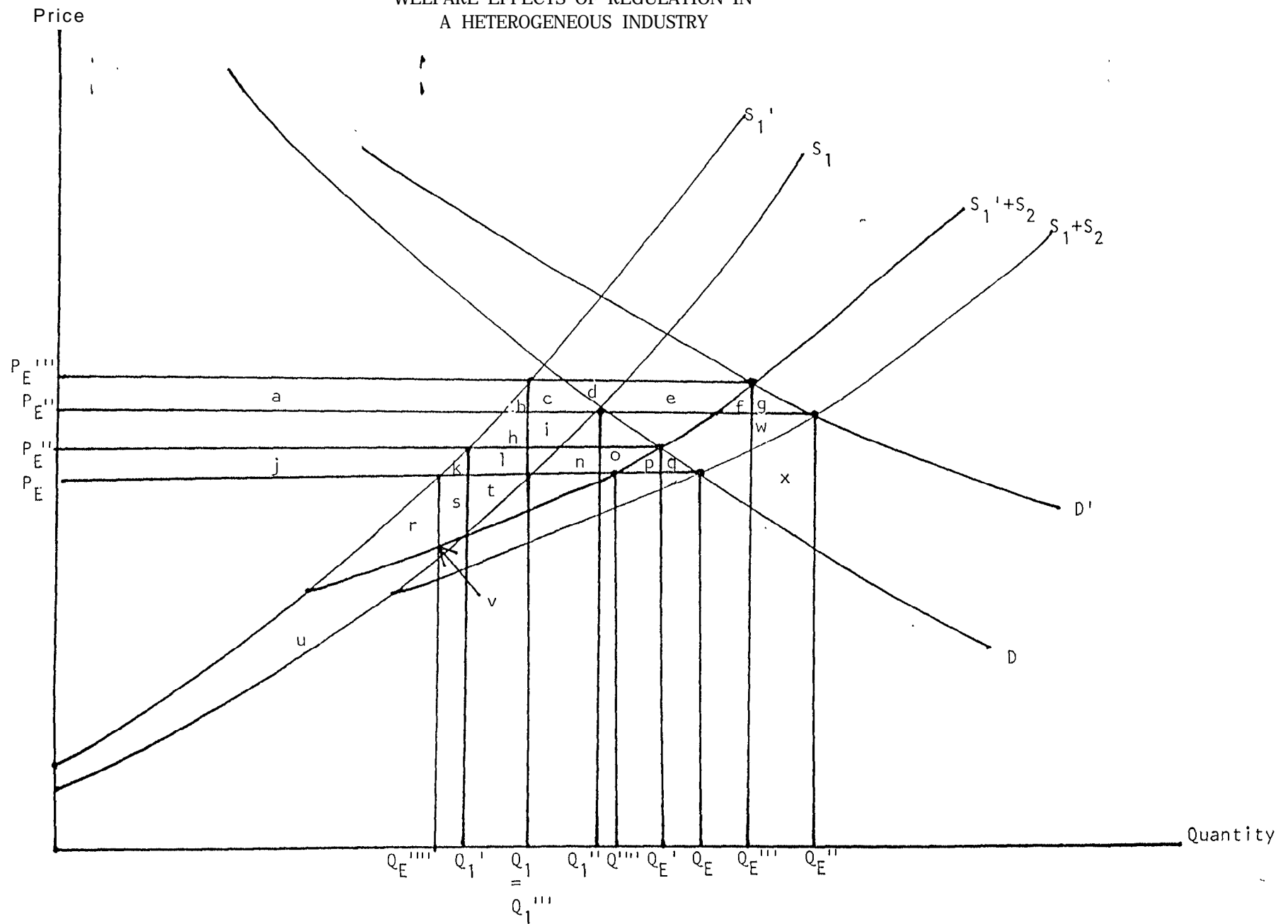
perfectly elastic at P_E , aggregate output will decline from Q_E to $Q_{E''}$. The output of Class 1 firms will decrease from Q_1 to Q_1' and the output of Class 2 firms will remain constant. Because of the increase in costs of production, Class 1 firms will suffer a loss of income equal to the area $r+s+t+u+v$; Class 2 firms and consumers, though, will be unaffected by the regulation.

The political economic implications of regulation in this situation are those accounted for in the standard aggregate welfare analysis, since the distribution of gains and losses (and, therefore, the distribution between supporters and opponents of regulations) will fall along the traditional lines of producers versus consumers. Producers affected directly by the regulation (Class 1 firms) suffer unambiguous losses and will thus tend to oppose regulation. Consumers' income is untouched; as long as regulation benefits consumers by improving environmental quality, transportation safety, product quality etc. they will tend to support regulation. Class 2 firms experience no income changes; however, they might be expected to oppose regulation because of the threat that future regulation may pose to them.

If, on the other hand, demand is downward sloping (like the curve D in Figure 1), the regulation will have price effects as well as this cost effect. Imposition of the regulation will cause the equilibrium price rise from P_E to P_E' . Aggregate output will fall from Q_E to Q_E' . The output of Class 1 firms will decline from Q_1 to Q_1' ; the output of Class 2 firms, though,

FIGURE 1

WELFARE EFFECTS OF REGULATION IN
A HETEROGENEOUS INDUSTRY



will increase. Because of the increase in price, Class 1 firms will receive a gain in income equal to the area j which at least partially offsets the cost effect $r+s+t+u+v$. Class 2 firms experience the price effect only, receiving an increase in income equal to the area $k+l+m+n+o$. Consumers, meanwhile, lose income equal to the area $j+k+l+m+n+o+p+q$. When regulation has both price and cost effects, the political-economic situation should change. The only unambiguous gainers from regulation will be Class 2 firms which gain both market share and income as shown in Figure 1. Class 1 firms lose on the cost side and gain on the price side; the net effect of regulation on their income cannot be determined a priori. The situation of consumers is similarly ambiguous. Consumers lose income equal to the total gains of all producers plus a dead weight loss; however, they gain in terms of enhanced environmental quality, product quality, transportation safety, etc. In short, the presence of price effects forces consumers to confront a fairly direct tradeoff between monetary income and regulatory benefits evaluation in those terms.

The political-economic implications of this scenario are rather striking. The presence of price effects makes consumers more aware of the costs of regulation and thus can be expected to reduce consumers' support for regulatory activity. Producers unaffected directly by regulation, on the other hand, have the most to gain from regulation and should number among the staunchest supporters of regulatory activity. In any case, even producers affected directly by regulation stand to gain from regulation and may support regulatory activity. These patterns

of regulatory income effects suggest that one should observe coalitions of some producers and some consumers in favor of regulation and some producers and some consumers opposed to regulation. Producers in regions not threatened by regulation should be expected to work with consumers who place a high value on regulatory benefits to promote regulation; producers directly affected by regulation should be expected to work with consumers who value regulatory benefits more lightly to oppose regulation. Clearly, these types of coalitions are a far cry from those described by the standard aggregate welfare approach.

The Impacts of Prior Regulations and Trade Conditions

In many important instances, market clearing is affected profoundly by factors exogenous to the regulatory process, for example, trade conditions, trade-related policies and regulatory programs under the jurisdiction of other agencies. The feasibility of establishing any particular set of regulatory measures may well depend critically on this exogenous environment. Thus it is essential for regulatory welfare analysis to incorporate the effects of these exogenous factors on the intraindustry and intersectoral impacts of proposed regulatory measures. This section examines the effects of two important classes of exogenous factors: revenue support programs and trade conditions/trade-related policies.

Revenue Support Programs

Revenue support programs are one of the most common forms of regulation in the U.S. They are perhaps best known in the context of agriculture - both price supports for grains and

marketing orders for fruits, vegetables and fresh milk fall into this category. They are not, however, restricted to agriculture: import quotas, which also belong to this class, apply to many industries and are, in fact, becoming increasingly widespread.

These programs are intended as a means of augmenting and stabilizing producers' incomes, especially in markets where demand is inelastic. They accomplish these aims by increasing both the level and the elasticity of demand. These effects are depicted in Figure 1 by the shift in demand from D to D' : $D' > D$ everywhere and $D' - D$ increases as output increases.² The pre-regulation equilibrium price rises to P_E'' . Pre-regulation aggregate output increases to Q_E'' ; the pre-regulation outputs of both Class 1 and Class 2 firms increase as well ($Q_1'' > Q_1$, $Q_E'' - Q_1'' > Q_E - Q_1$).

Regulation affecting Class 1 firms in this case causes the equilibrium price to rise to P_E''' and aggregate output to fall to Q_E''' . Production of Class 1 firms will fall to Q_1''' while the output of Class 2 firms will increase. Because demand is more elastic under the revenue support program, the price effects of regulation on both Class 1 and Class 2 firms will tend to be smaller than before ($a < j$, $b+c+d+e < k+l+m+n+o$);³ thus, both classes of producers will have less incentive to support regulation. Moreover, the cost effect of regulation on Class 1 firms will rise because of the increase in output: $b+c+d+h+i+k+l+m+r+s+t+u+v$ exceeds $r+s+t+u+v$ by an amount equal to the area $b+c+d+k+l+m$. The net effect of the revenue support program, then, will be to entrench more firmly all producers' opposition to regulation.

Revenue support programs have a twofold effect on consumers' attitudes towards regulation. First, by reducing the price effect of regulation, these programs reduce consumers' income losses from regulation and hence the effective cost of any regulatory benefits. Second, regulation in this context will actually increase consumers' income to a certain extent by reducing the costs imposed on consumers by the revenue support programs. As Lichtenberg and Zilberman (1985) have shown, revenue support programs force consumers to spend either directly or indirectly (e.g., through tax payments) more than their willingness to pay for the good (as indicated by the demand curve D). Regulation reduces these excess expenditures, thereby augmenting consumers' income. In Figure 1, for example, these savings on excess purchases equal the area $g+w+x$; losses from regulation equal the area $a+b+c+d+e+f+g$; and thus the net effect of regulation on consumers' income equals $w+x-(a+b+c+d+e+f)$.

In sum, revenue support programs will at the very least enhance consumers' support for regulation by mitigating any losses in their income induced by regulation. At the maximum, they may even create a positive inducement for consumers to support regulation: if the reductions in excess expenditures caused by regulation are large enough, consumers' income will actually increase and the benefits of regulation will acquire a negative effective cost. Nor is such a scenario unlikely: under a price price support scheme, for example, the reductions in revenue support costs caused by regulation always exceed consumers' losses more narrowly defined. Thus, by exaggerating

both consumers' gains from regulation and producers' losses, revenue support programs will tend to create a sharper polarization around proposed regulations than competitive equilibrium welfare effects might indicate.

How these forces operate can be seen perhaps most strikingly in the context of environmental regulation of agriculture. Current farm programs combine a guarantee of a minimum price (called the target price) to farmers as a means of revenue support with restrictions on land use (acreage set asides) as a means of supply control. Combined, these two factors give farmers a powerful incentive to increase output by increasing their reliance on inputs like fertilizers, pesticides and irrigation - precisely those inputs which have the most profound adverse impacts on environmental quality (Zilberman (1985)). One can see that these farm programs deliver a double whammy to environmental quality by promising farmers to pollute more at the same time as they build up farmers' stake in continuing those polluting activities. Moreover, by making demand essentially perfectly elastic at the target price, these programs remove any basis for intersectoral coalitions of non-polluting producers with consumers in support of environmental regulation.

On the other side of the coin, public support for stepped-up environmental regulation of agriculture has mounted in recent years, precisely as the costs of these farm programs have escalated. Some commentators have gone so far as to suggest explicitly that environmental regulation be used as a means of curbing the costs of these programs (Crosson and Benbrook

(1984)). This thinking is also reflected in the current farm bill, which expands the use of environmental quality criteria as a means of determining set asides.

Trade-Related Policies

In recent years, the U.S. economy has become considerably more open; foreign trade has emerged as an increasingly important determinant of overall market conditions in many industries. Thus, policies which affect trade conditions either directly or indirectly (budget deficits) will tend to exert a significant degree of influence on the welfare effects of regulation.

Consider the case shown in Figure 1. If the industry is a net exporter, the initial demand curve D will represent a combination of foreign and domestic demands; if the country is a net importer, then D represents the excess demand for domestic output. In either case, as trade conditions improve, (e.g., through a fall in exchange rates) demand will shift to a curve like D' which is both higher and more elastic than D. As before, the price effects on all producers' and consumers' income will diminish while the cost effect on the income of Class 1 firms will increase. A worsening of trade conditions (e.g., through a rise in exchange rates) will produce the opposite effect: demand will decrease and becomes less elastic; the cost effect on the income of Class 1 firms will decrease; the price effect on the incomes of both classes of firms will increase; and the loss in consumers' incomes will decline.

This analysis suggests that support for regulation will be much stronger when trade conditions are poor since firms not

directly affected by regulation stand to gain more and firms directly affected by regulation stand to lose less than in better times. Regulation under these conditions functions much like a cartel (as suggested by Stigler) which serves to cushion the impact of hard times by providing a mechanism for restricting output and prorationing production. Moreover, because consumers' potential losses from regulation also fall, opposition to regulation should diminish as well. As trade conditions improve, though, the gains of firms not directly affected by regulation will shrink and the losses sustained by firms directly affected and by consumers will grow and regulation will become much less attractive.

An Empirical Example: The U.S. Cotton Industry

As noted above, agriculture is one industry characterized by marked heterogeneity among producers. It is especially interesting for the present purpose because this heterogeneity is principally regional and hence parallels the basic structure of domestic U.S. politics. Also of interest is the fact that regulation may have strikingly different effects in different regions. Banning the use of a particular pesticide may have a significant impact on productivity in some regions (e.g., where it is used heavily) and no direct impact others (e.g., where the pest it is used against does not pose a serious threat). For example, the pesticide chlordimeform is used both in the Western desert areas against the pink bollworm and in the Delta against *Heliothis zea* and is not used at all in the two remaining two regions. A ban on chlordimeform, then, would impose one set of

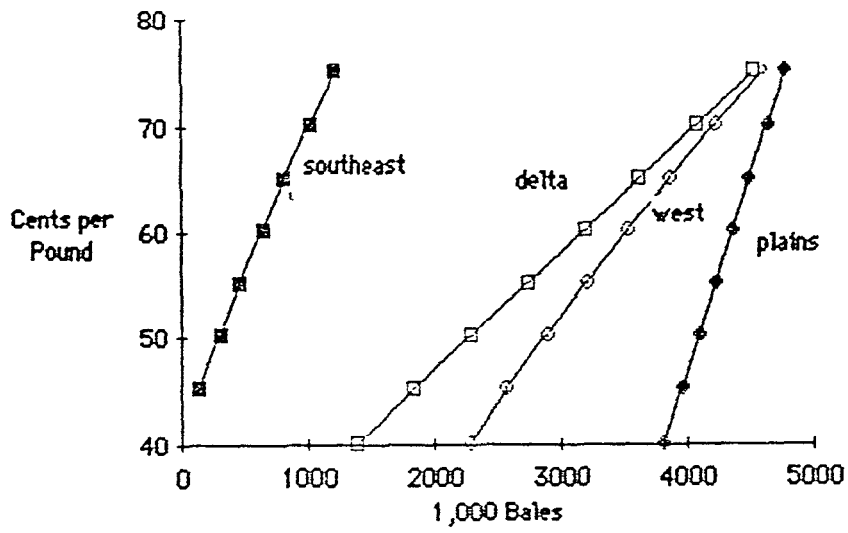
cost and/or yield changes in the West, another in the Delta, and none in the Plains or Southeast.

To study the intraindustry effects of regulation, we focused on- the U.S. cotton industry during the late 1970s. Differences in productivity among the four major producing regions (the Southeast, the Delta, the Plains and the West)⁴ of this industry are quite notable. Supply curves for each of these regions were taken from Evans and Bell (1978). In each region, supply was estimated as the product of yield and acreage. Acreage was estimated as a function of the price of cotton, cotton production costs, an opportunity cost equal to the revenue of an alternative crop forgone⁵ and government policy variables; during the study period, however, government programs were not effective and so the latter variables were ignored. Yield was estimated as a function of cotton price, production cost, acreage and a set of variables reflecting weather conditions. Demand was estimated separately for each of three separate demands for the years 1970-1980: domestic consumption, exports and net carryover. Domestic demand was estimated as a function of the domestic cotton price, exports and net carryover as functions of the domestic price and the SDR/U.S. dollar exchange rate.

The regional supply curves estimated for 1978 are pictured in Figure 2. Quantities in each region have been standardized according to cotton quality, so that all can be depicted on a single price axis. The dwindling role of Southeastern cotton relative to its historic role is immediately striking. This is explained in part by the rapid diffusion of a more profitable

Figure 2.

Regional Supply 1978



alternative, the double-cropping of wheat and soybeans, in recent years. Among the other three regions, roughly similar levels of output at the 1978 market price, which was 58.1 cents per pound, are seen to result from very different production patterns. The Plains, which in general is characterized by low-cost, low-yielding dryland cotton, is seen to be most price-inelastic. The relatively low sensitivity of production to market fluctuations, suggests among other things that the alternative crop may be unattractive over much of the land base. The Delta and the West are far more price elastic, with cotton production in the Delta being particularly volatile. However, the two regions differ in important respects. Western production is based on extremely high costs and yields and depends crucially on regional water projects, which often permit irrigation at costs well below even the cost of delivery.

Supply and Welfare Elasticities of Regulatory Response

Because of intraindustry heterogeneity, the impact of regulation on productivity and/or cost is often quite complex. In the case at hand, the four U.S. cotton producing regions differ considerably in climate. Each has different primary pest problems and hence different pesticide use patterns. The West relies on irrigation while the other three rely mainly on dryland cultivation. Differences in soils, weather, and so on lead to other differences in cultivation practices as well. Under these conditions, even regulations which are uniform nationally will have different impacts on productivity and/or cost in the different regions. A ban on the use of a pesticide like

chlordimeform will, as we have seen, decrease yields and/or increase costs in the Delta and the West but nowhere else. Reductions in federal irrigation water subsidies would increase costs in the West but leave costs elsewhere untouched. Similarly, the effects of regulation-induced price changes on supply and growers' income differ across regions because of differences in the elasticity of supply.

The complexity of these effects makes it important to have general information about the effects of decreases in productivity or increases in cost in one region on supply and welfare in all regions. This information is provided by the elasticities and cross-elasticities of supply and welfare in response to decreases in productivity or increases in cost, measures we term the supply and welfare elasticities of regulatory response and define as the percentage changes in supply and welfare due to a 1% decrease in productivity or increase in cost. The elasticity form is especially useful because it allows ready comparison of the different effects. Moreover, these elasticities can be used to derive a first-order estimate of the supply and welfare impacts of any proposed regulation.

Table 1 illustrates the effects across all cotton-producing regions of a hypothetical regulation which in 1978 would have caused the cost of producing cotton in the Delta region to increase by one percent, while leaving cost and productivity in the other three regions unaffected. Changes in absolute quantity are given above, with the equivalent percentage changes in

Table 1.

Changes in Price and Quantities from a 1% Cost Increase in Delta

(Price in Dollars, Quantities in Millions of Bales)

Price	-----Supply-----				---Demand---		
	Southeast	Delta	Plains	West	TotalProd	Foreign	Domestic (+NetCarryover)
.0016 (.3%)	5.44 (.9%)	-43.15 (-1.4%)	4.77 (.1%)	10.18 (.3%)	-22.76 (-.2%)	-2.08 (-.03%)	-20.68 (-.1%)

Changes in Surpluses and Export Revenue

(Millions of Dollars)

Southeast	Delta	Plains	West	Total Producer Surplus	Domestic Consumer Surplus	Net Domestic Surplus	Export Revenue
0.5 (1.7%)	-8.1 (-3.3%)	3.0 (.4%)	2.6 (.5%)	-2.1 (-.1%)	-1.0 (-.2%)	-3.1 (1.5%)	4.1 (.2%)

parentheses below. Since the experiment posits a 1% change in cost, the percentage changes may be interpreted as elasticities, so that the own supply elasticity of the regulation is -1.4, while the own welfare elasticity is -3.3. The standard procedures used to estimate the welfare effects of such a regulation would give an estimate of the overall effect, a loss of 3.0 million, and of its intersectoral distribution, a loss to producers of \$2.1 million and a loss to consumers of \$1.0 million. Just how partial this picture is is readily apparent. The losses borne by growers in the Delta are almost four times the aggregate producer loss. The gains registered by growers in the Plains and the West are substantial: both are larger in absolute value than the aggregate loss and each amounts to close to a third of the absolute size of the loss suffered by Delta producers. The small size of the aggregate loss suffered by producers (0.1%) is rather misleading, as it gives no indication of the fact that the regulation creates a significant redistribution of income among producers, trading large losses to Delta growers (3.3%) for reasonable gains by growers in the Plains (0.4%), the West (0.5%) and the Southeast (1.7%; the large size of the percentage change here is due mainly to the small size of this region's share of production).

Also noteworthy is the fact that the regulation actually increases export revenues, an effect which occurs because export demand is extremely inelastic with respect to the U.S. market price of cotton. This indicates that a significant share of the welfare cost of regulation affecting cotton is shifted onto

foreign consumers and suggests that, surprisingly, such regulation will have the beneficial side-effect of helping reduce the U.S. trade deficit.

Table 2 shows the elasticities of supply and demand for cotton with respect to a 1% increase in cost and a 1% decrease in yield in each of the four producing regions under the economic conditions of 1978. Note that either regulatory effect has very different impacts on supply in the different regions. Supply in the Southeast is extremely sensitive, reflecting the close competition for land with double-cropping of wheat and soybeans and the small size of the cotton acreage base in the region. The Delta is also quite sensitive, indicating that the profitability of soybeans is close to that of cotton.

Also different are the responses of total U.S. supply to regulations affecting different regions. Aggregate supply is most sensitive to changes in the Delta because of that region's supply sensitivity to regulation and its large share of total production. The Southeast has a very small impact on total production because of its small share. The Plains and the West have smaller impacts on the total because their supply is less sensitive to regulation.

Decreases in yield obviously have a much larger impact than increases in cost. This arises because production costs tend to be constant on a per acre basis, so that changes in yield affect both productivity and unit costs. Interestingly, production in the Plains is rather sensitive to changes in yield even though it is quite insensitive to changes in cost. This probably arises because of the low yields in that region.

Table 2.

Elasticities of Supply, Demand and Price Under Regulation, 1978

From a 1% Increase in Cost

Affected Region:	Price	SE	Delta	Plains	West	Total Supply	Foreign Demand	Domestic Demand
SE	.10	-3.14	.17	.04	.11	-.08	-.01	-.04
Delta	.28	.92	-1.42	.12	.31	-.21	-.03	-.11
Plains	.06	.19	.10	-.29	.06	-.04	-.01	-.02
West	.08	.28	.15	.04	-.44	-.06	-.01	-.03

From a 1% Decrease in Yield per Acre

SE	.12	-3.71	.20	.05	.13	-.09	-.01	-.05
Delta	.43	1.42	-2.18	.19	.48	-.33	-.05	-.17
Plains	.28	.94	.49	-1.41	.32	-.22	-.04	-.11
West	.20	.66	.35	.09	-1.04	-.15	-.02	-.08

One can see that in every case, regulation causes small changes in aggregate supply but significant changes in the distribution of production and consumption. In every case, the effect of regulation on aggregate U.S. supply is only about 15% of the effect on the region in which costs were increased or yields reduced.

One can see that the cross-elasticities of regulatory response each region may be rather large compared (in absolute value terms) to the region's own-elasticity of regulatory response as well. The West and the Delta are especially striking in this regard. For example, a 1% cost increase in the Delta will increase supply in the West by 0.31%; a 1% cost increase in the West will reduce supply there by 0.44%, only a third again as much. A 1% yield decrease in the Delta will increase supply in the West by 0.48%, about half of the size of the decrease in supply caused by a 1% decrease in yield in the West.

Finally, note the insensitivity of foreign demand to regulation: even with price increases of 0.43%, foreign demand declines only 0.05%.

Table 3 shows the welfare elasticities of responses to regulations affecting cost and yield in each of the four cotton-producing regions. The patterns discernible in the supply elasticities shown in Table 2 are evident here also. Producers' surplus is even more sensitive to regulation than supply in the three regions whose supply is more elastic (Southeast, Delta, West) and less so in the Plains, whose supply is the most inelastic. Interestingly, the net welfare effect of regulation

Table 3.

Welfare Elasticities 1978

From an Increase in Cost

Affected Region	SE	Delta	Plains	West	Total Prod. Surplus	Domestic Consumer Surplus	Net Domestic Surplus	Export Revenue
SE	-6.08	.17	.13	.19	.05	-.08	.02	.09
Delta	1.71	-3.29	.36	.54	-.13	-.22	-.15	.24
Plains	.35	.10	-.13	.11	-.01	-.05	-.02	.05
west	.52	.15	.11	-.73	-.13	-.07	-.12	.07

From a Decrease in Yield per Acre

SE	-6.61	.20	.15	.22	.07	-.09	.03	.10
Delta	2.65	-4.08	.55	.83	-.05	-.34	-.12	.37
Plains	1.75	.49	-.63	.55	-.06	-.22	-.10	.25
West	1.24	.35	.26	-1.31	-.18	-.16	-.18	.18

increasing costs or decreasing yields in the Southeast is positive, suggesting that the current trend away from cotton production in that region is beneficial.

Sensitivity of Regulatory Impacts to Trade Conditions

For a heavily traded commodity such as cotton the effects of regulation may be expected to vary as macroeconomic policy and international factors cause the exchange rate to rise or fall. To examine the sensitivity of regulatory responses to the exchange rate, we reproduce in Table 4 the welfare elasticities with respect to yield decreases in each of the 4 producing regions together with the equivalent elasticities under exchange rate 25% higher and 25% lower than that of 1975.

As the exchange rate falls, the own- and cross-elasticities of producers' surplus tend to fall as well. Generally speaking the changes are rather small. The Southeast and the Delta are the most sensitive, probably because supply in these two regions is quite elastic. While supply in the West is also relatively elastic, a large proportion of its production is a very high quality of cotton which trades to a certain extent on a separate market and thus insulates the region somewhat from exchange rate fluctuations. In the Plains, the region with the most inelastic supply, the variations in welfare elasticities are negligible.

Note that only in the Plains does a fall in exchange rates increase the own-elasticity of welfare response and decrease the cross-elasticity, as the theoretical discussion above would seem to indicate should be the case overall. This apparent contradiction is caused by the use of elasticities: when

Table 4.

Welfare Elasticities of Yield-Reducing Regulations

With Exchange Rates 25% Above Historic Levels

Affected Region	SE	Delta	Plains	West	Total Prod. Surplus	Domestic Consumer Surplus	Net Domestic Surplus	Export Revenue
SE	-10.44	.24	.16	.23	.11	-0.08	.05	.11
Delta	4.04	-4.46	.59	.88	-0.06	-0.30	-0.13	.40
Plains	2.79	.63	-.59	.61	-0.03	-0.21	-0.08	.28
West	1.88	.42	.27	-1.40	-0.18	-0.14	-0.17	.19

With Exchange Rates at Historic Levels

SE	-6.61	.20	.15	.22	.07	-.09	.03	.10
Delta	2.65	-4.08	.55	.83	-.05	-.34	-.12	.37
Plains	1.75	.49	-.63	.55	-.06	-.22	-.10	.25
West	1.24	.35	.26	-1.31	-.18	-.16	-.18	.18

With Exchange Rates 25% Below Historic Levels

SE	-4.92	.18	.15	.22	.04	-0.10	.01	.10
Delta	2.05	-3.84	.52	.79	-.03	-0.37	-0.09	.35
Plains	1.31	.41	-0.66	.50	-0.08	-0.24	-0.11	.22
West	.96	.30	.25	-1.23	-0.19	-0.18	-0.09	.16

exchange rates fall, pre-regulation producers' surplus is higher and a larger loss from regulation may constitute a smaller proportion to the total. This in fact is what happens; examination of the figures on absolute changes in producers' surplus indicates that the losses in the regions directly affected by regulation increase in every case. Interestingly, the price effects on the regions not directly affected increase in a number of cases as well. This phenomenon is probably due to the increase in output caused by a fall in exchange rates, coupled with the fact that the price increase caused by regulation is not much smaller. The impact of exchange rates on the own- and cross-effects of regulation affecting a simple region are non-negligible: a 25% decrease in exchange rates may increase either by 1.5-2.9%, suggesting an exchange-rate elasticity of 0.06-0.08%.

Conclusion

This paper has argued that standard aggregate welfare analyses based on competitive market clearing often give a very partial, and sometimes a misleading, picture of the impacts of regulation. Theoretically, it was shown that the intraindustry effects of regulation (which are ignored by the standard approach) may outweigh the intersectoral effects typically estimated and that consequently one would often expect a different political-economic situation than predicted by the standard approach. Incorporation of exogenous factors like revenue-support programs or shifts in trade conditions also produced different distributional effects and political-economic scenarios than predicted under the standard approach.

An empirical analysis of regulations affecting U.S. cotton production demonstrated that these differences may be non-negligible. The analysis made use of two new measures of regulatory impact, the supply and welfare elasticities of regulatory response, which permitted easier interpretation, comparison and extension of the results. Regulations having to slight aggregate effects were shown to have quite profound distributional consequences. These impacts were also shown to be sensitive to shifts in trade conditions.

Taken together, these results suggest that regulators have perhaps had good reasons for their resistance to blanket acceptance of standard welfare measures and that the task facing economists is to modify the standard framework to address real regulatory concerns.

Footnotes

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²In the case of agricultural price supports, the difference between average revenue and demand represents an explicit subsidy paid out of tax revenues. Agricultural marketing orders essentially set up discriminating monopoly schemes for allocating an industry's output among markets so that the pooled price (average revenue) producers receive exceeds demand. Import quotas effectively increase domestic excess demand above competitive levels, i.e., above the levels specified by the difference between domestic demand and foreign supply. The precise interpretation of the welfare effects of regulation under such conditions will vary according to these distinctions.

³The overall price effect of regulation will tend to decrease even though pre-regulation output will be larger under a revenue-support program. To see why, write the price effect as $T_i =$

$\int_{P_E}^{P_E'} S_i(P) dP$ and demand as a increasing function of price and a shifter t representing the level of revenue support. It is easy to show that $dT_i/dt = Q_i'(dP_E'/dt) - Q_i(dP_E/dt)$ which will be negative as long as Q_i'/Q_i is less than $(dP_E/dt)/(dP_E'/dt)$. From the market equilibrium condition, $dP_E/dt = (dD/dt)/((dS/dt) - (dD/dP))$. The nature of the revenue support program suggests that $dD(P_E)/dt$ is greater than $dD(P_E')/dt$; thus, as long as the slope of the excess supply curve at P_E' is not too much smaller than the slope at P_E , dP_E/dt will be greater than dP_E'/dt . Since Q_i' is smaller than Q_i , this will ensure $dT_i/dt < 0$.

⁴The Delta states are Arkansas, Louisiana, Mississippi, Missouri and Tennessee; the Southeast consists of Alabama, Georgia, North Carolina, and South Carolina; the Plains states are Texas and Oklahoma; and the West is California, Arizona, and New Mexico.

⁵The alternative crops used in the model were: soybeans in the Delta; corn and soybeans in the Plains; barley in the West; and double-cropped wheat and soybeans in the Southeast.

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D. CONCLUSION

It is evident from Sections B and C that considerable progress was made in developing models for estimating the benefits of pesticide use which reflect the regional heterogeneity of pesticide use and the impacts of agricultural policies. The extent of this progress in the applied area is reflected in the existence of working empirical models for important crops incorporating each of these considerations and, in the case of agricultural policy, in the development of IBM PC-compatible software for calculating welfare effects under deficiency payments delivered to EPA in December 1985.

It is equally apparent that considerable further work is necessary to meet the needs of EPA analysts. A first task, of course, is the integration of these two frameworks, i.e., the development of a single empirical apparatus capable of delivering estimates of regional effects of regulation and impacts of farm policies simultaneously. Equally important is the need for further refinement in the characterization of agricultural policy. As a first step, we examined the most important component of farm programs in recent years, deficiency payments. However, agricultural policy contains several additional components such as requirements to idle certain amounts of land (set asides) to be eligible for deficiency payments, the buffer stock/crop loan program, which essentially sets a floor under market prices, and so on.

The development of such an integrated model incorporating the key features of agricultural programs is a big econometric

challenge. The simultaneous incorporation of set asides and deficiency payments is particularly difficult: a number of investigators have tackled this endeavor in recent years and none of their solutions is fully satisfactory. It is this aspect to which we propose to pay the most concentrated attention during the subsequent budget period (see V below).

To make the results of our work fully accessible to EPA, our models will have to be used to develop software for use by EPA analysis. We expect in addition to update the software we have already developed to take into account factors such as loan rates.